Argonne NATIONAL LABORATORY

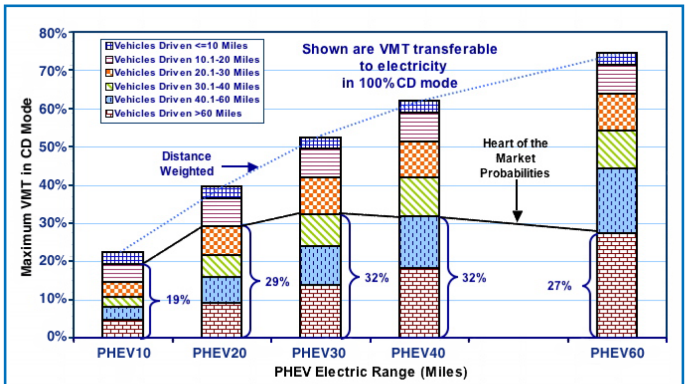
# Transportation R&D

# *PHEV Technology Analysis at Argonne*

To estimate the impact of plug-in hybrid electric vehicles (PHEVs) in the U.S., Argonne National Laboratory is analyzing typical travel behavior, new technology penetration patterns, and pathways for vehicle fuels. The analysis will lead to better understanding of:

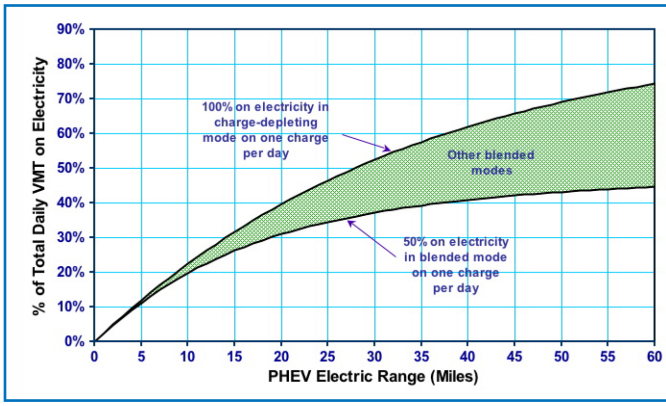
- Potential buyers of PHEVs,
- Patterns of charging PHEV battery packs,
- Potential for petroleum use reduction, and
- Well-to-wheel energy and greenhouse gas emissions implications.

## Heart of the market concept




Combining PHEV simulation results with evaluation of travel behavior from a national survey, Argonne researchers developed the "Heart of the Market" concept. This concept eliminates vehicles that travel less than a PHEV's electric range per day, since a PHEV is not cost effective for these customers. Combining this insight with various PHEV range values and customer driving patterns, we estimated that ~20 miles is the most effective PHEV range for reducing oil use, if only one type of PHEV is produced.

## 100% electric vs. blended mode operation




PHEVs could transfer a substantial part of the nation's daily vehicle miles to electricity. However, its electric storage system and electric drive components increase its purchase price, diminishing marketability. If we value cost-effectiveness, early PHEVs would have smaller, less powerful electric drives and battery packs. Such PHEVs are likely to operate in blended mode, which will extend the daily driving distance needed to complete at least one battery pack discharge per day. This pushes the early target market toward consumers with longer daily driving distances.

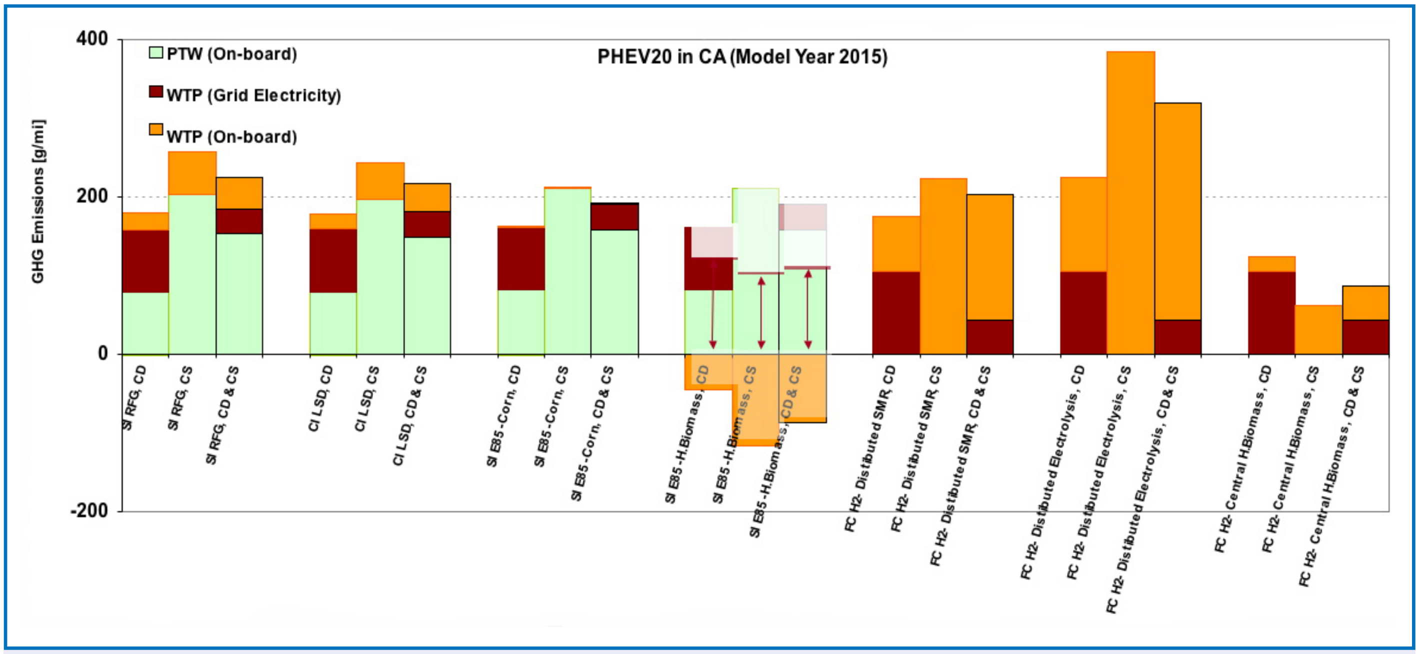
## PHEV battery pack charging

Most PHEVs are charged overnight. If PHEVs are charged more than once a day, more miles can be transferred to electricity and cost effectiveness improved. Argonne analysis of the longest vehicle parking time between 6 AM and 6 PM showed that 66% of the vehicles driven to work are parked more than three hours before noon, potentially allowing a second charge before the electric utility peak demand begins. For shopping, parked times were short and parking was often during peak electric demand.

## Well-to-Wheel implications

Argonne's GREET model has been used to calculate the well-to-wheel (WTW) energy use and greenhouse gas (GHG) emissions of charge depleting (CD) and charge sustaining (CS) operational modes of PHEVs with powerful all-electric drive and to compute their weighted average using the vehicle mile traveled (VMT) share in each mode. With the exception of biomass-based fuels, CD blended mode operation of PHEVs provides significant energy and GHG emissions savings compared to the CS operation using an efficient, low-carbon intensity marginal mix such as that of California. PHEVs using fuels produced from biomass sources and operating in CD mode may produce less GHG emissions than that in CS operational mode only if the electricity is generated from non-fossil or renewable sources.

Using an all-electric range (AER) between 10 and 40 miles, PHEVs using petroleum fuels (gasoline and diesel); a blend of 85% ethanol and 15% gasoline (E85); and hydrogen offer a 40–60%, 70–90% and over 90% reduction in petroleum energy use and a 30–60%, 40–80% and 10–100% reduction in GHG emissions, respectively, relative to an internal combustion engine vehicle using gasoline. The PHEVs analyzed also reduce petroleum energy use compared to regular hybrid electric vehicles (HEVs). More petroleum energy savings are realized as the electric range increases, except when the marginal grid mix is dominated by oil-fired electricity. GHG emissions benefits may not be realized for such PHEVs when employing biomass-based fuels (biomass-E85 and hydrogen) compared to regular HEVs if the marginal grid mix is dominated by fossil sources. Such PHEVs employing hydrogen produced via electrolysis may provide GHG emissions benefits over other PHEV vehicle/fuel systems only if the source of electricity is non-fossil (nuclear, biomass, or renewable).




*For E85 from biomass, the net GHG emissions after biocycle accounting is shown by red arrows.*

**For further information, contact**

Dan Santini
dsantini@anl.gov

Michael Wang
mqwang@anl.gov

November 2008

UChicago ▸ Argonne LLC

Argonne National Laboratory is a U.S. Department of Energy laboratory managed by UChicago Argonne, LLC

U.S. Department of Energy
Energy Efficiency and Renewable Energy
Bringing you a prosperous future where energy is clean, abundant, reliable, and affordable